Improving Freezing Tolerance of Cold-Sensitive Grape Cultivars Using Abscisic Acid

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Abstract

The goal of this study was to improve freezing tolerance of sensitive grape cultivars using abscisic acid (ABA). In the field, we evaluated the effect of exogenous ABA on freezing tolerance and optimum timing of ABA application of *Vitis vinifera* 'Pinot gris'. 'Pinot gris' grapevines were treated with 400mg/L ABA at different stages of development (veraison, post-veraison and post-harvest). The application of ABA did not affect yield components or fruit composition, but caused early leaf abscission, advanced bud dormancy, decreased bud water content, and eventually increased freezing tolerance. In the greenhouse experiment, freezing tolerance (expressed as LT50), water content, and soluble sugars in *Vitis vinifera* 'Cabernet Franc' buds were measured 24h, 48h, 1w, 2w, 4w after ABA application. Results showed that ABA caused desiccation of buds which was associated with increased freezing tolerance. Ultimately, the findings of this project are valuable to grape producers to provide another tool for freeze protection and to the scientific community for better understanding of the mechanisms of freezing tolerance.

Introduction

Grape and wine industries in colder regions such as Ohio have been expanding rapidly and demand for premium wine grapes has also increased. However, several popular cultivars are sensitive to freezing temperatures below -20 ℃. Therefore, it is of critical importance to understand and improve the freezing tolerance of sensitive grapevines. The objectives of this research are to: 1) evaluate the responses of greenhouse- and field-grown wine grape cultivars to exogenous ABA, 2) characterize the changes of freezing tolerance and water content in bud tissues of greenhouse- and field-grown vines in response to exogenous ABA.

Materials and Methods

❖ **Materials:** *Vitis vinifera* 'Pinot gris' (field) and 'Cabernet Franc' (greenhouse).

❖ **Field Experiment:**

ABA Treatments and Timing of spray applications

1) Control (deionized water with 0.05% Latron B1956)
2) 400 mg/L ABA+0.05% Latron B1956 @ Veraison (08/16/2012) (8/21/2013)
3) 400 mg/L ABA+0.05% Latron B1956 @ Post veraison (08/31/2012) (9/17/2013)
4) 400 mg/L ABA+0.05% Latron B1956 @ Post harvest (09/28/2012) (10/11/2013)

Data collection:

- **Yield components**
  Cluster number, cluster weight, yield per vine, 100 berry weight
- **Fruit composition**
  %soluble solids, pH, total acid
- **Leaf senescence and abscission**
  SPAD meter, abscised leaves per vine
- **Bud dormancy**
  Number of days to 50% bud break
- **Bud freezing tolerance in fall-winter**
  LT50s (freezing tests were conducted from Aug 2012 to Mar 2013 in year 1 and Sep 2013 to Nov 2013 in year 2)

❖ **Greenhouse Experiment:**

LT50s and water contentin *Vitis vinifera* 'Cabernet Franc' buds were measured 24h, 48h, 1w, 2w, 4w after ABA application.

Results

Field Experiment:

1) ABA did not affect yield components or fruit composition (Tables 1, 2)

2) ABA caused early leaf senescence and abscission. ABA application at post-harvest showed the most significant effect (Fig. 1, 2).

4) ABA caused earlier and deeper dormancy and buds reached maximum dormancy on 17 Oct 2012 and 30 Oct 2013(Fig. 3).

5) ABA increased freezing tolerance of Pinot gris during the fall by 3.5 ℃, winter by 3.4 ℃, and early spring by 2.4 ℃. ABA application at veraison and post-veraison showed the most significant effect (Fig. 4).

Greenhouse Experiment:

1) ABA did not affect water content of buds 24h and 48h after ABA application. However, ABA-treated grapevines had 22% (1w) and 8%(2 w) less water content than in Control (Fig. 5).

2)ABA did not affect freezing tolerance 24h and 48h after ABA application. However, ABA improved freezing tolerance of buds by 4.2 ℃, 3.3 ℃ and 1.3 ℃ 1w, 2w, and 4w after ABA application, respectively (Fig. 6).

3) Bud desiccation and decreased LT50s both occurred 1w and 2w after ABA application.

Table 1: Yield components of Pinot gris in 2012 and 2013

	Treatment	Cluster number per vine	Cluster weight (lb)	Yield per vine (lb)	100 Berry Weight (g)
2012 Harvest (19 September)	Control	31a	0.22a	6.7a	160a
	Veraison	30a	0.20a	6.1a	166a
	Post Veraison	33a	0.21a	6.7a	155a
	Post Harvest	31a	0.21a	6.4a	164a
2013 Harvest (24 September)	Control	26a	0.25a	6.5a	158a
	Veraison	26a	0.27a	7.0a	153a
	Post Veraison	27a	0.26a	7.0a	157a
	Post Harvest	24a	0.24a	5.7a	147a

Table 2: Fruit composition of Pinot gris in 2012 and 2013

	Treatment	%Soluble Solids	pH	Total Acid (g/L)
2012 Harvest (19 September)	Control	23.4a	3.53a	6.54a
	Veraison	23.5a	3.54a	6.54a
	Post Veraison	23.2a	3.59a	6.50a
	Post Harvest	23.5a	3.50a	6.55a
2013 Harvest (24 September)	Control	19.8a	3.39a	6.49a
	Veraison	19.6a	3.50a	6.43a
	Post Veraison	19.7a	3.51a	5.86a
	Post Harvest	19.4a	3.43a	6.26a

(a) Control (b) Veraison (c) Post-veraison (d) Post-harvest

Figure 1. Leaf senescence of Pinot gris (09 Oct 2012)

(a) Control (b) Veraison (c) Post-veraison (d) Post-harvest

Figure 2. Leaf abscission of Pinot gris (17 Oct 2012)

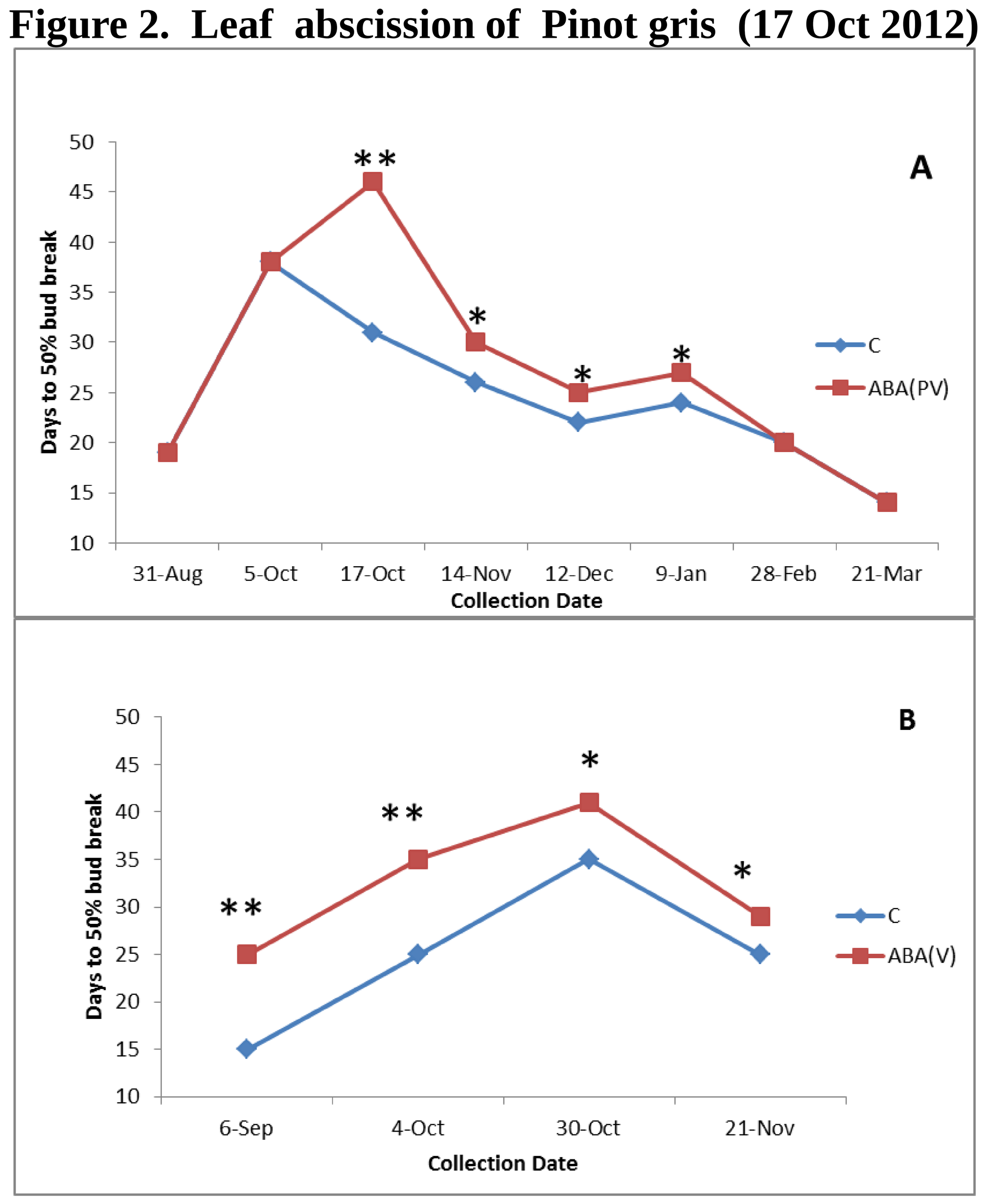

Figure 3. Effect of ABA on bud dormancy (Days to 50% Bud Break) of 'Pinot gris' grapevine during 2012-13 season (A) and 2013 (B).

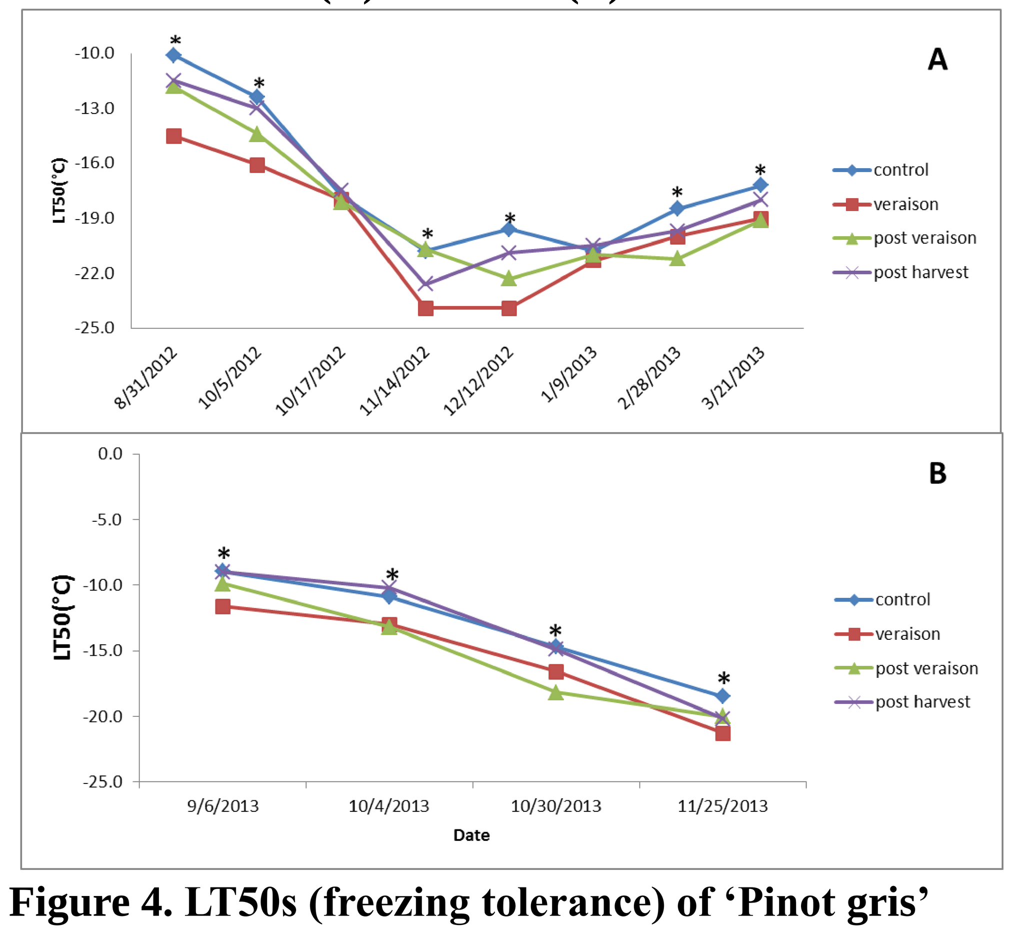

Figure 4. LT50s (freezing tolerance) of 'Pinot gris' with different ABA treatments in 2012-2013(A) and 2013 (B).

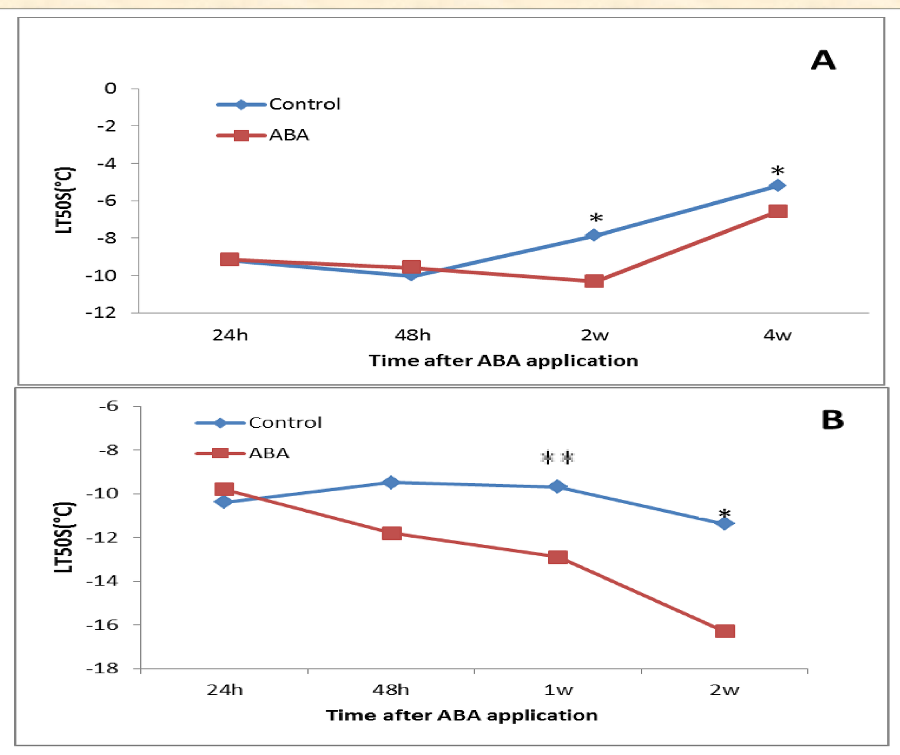

Figure 5. Effect of ABA on freezing tolerance of greenhouse-grown'Cabernet franc' grapevines, A) Experiment 1, conducted in July, 2013, B) Experiment 2, conducted in Nov, 2013.

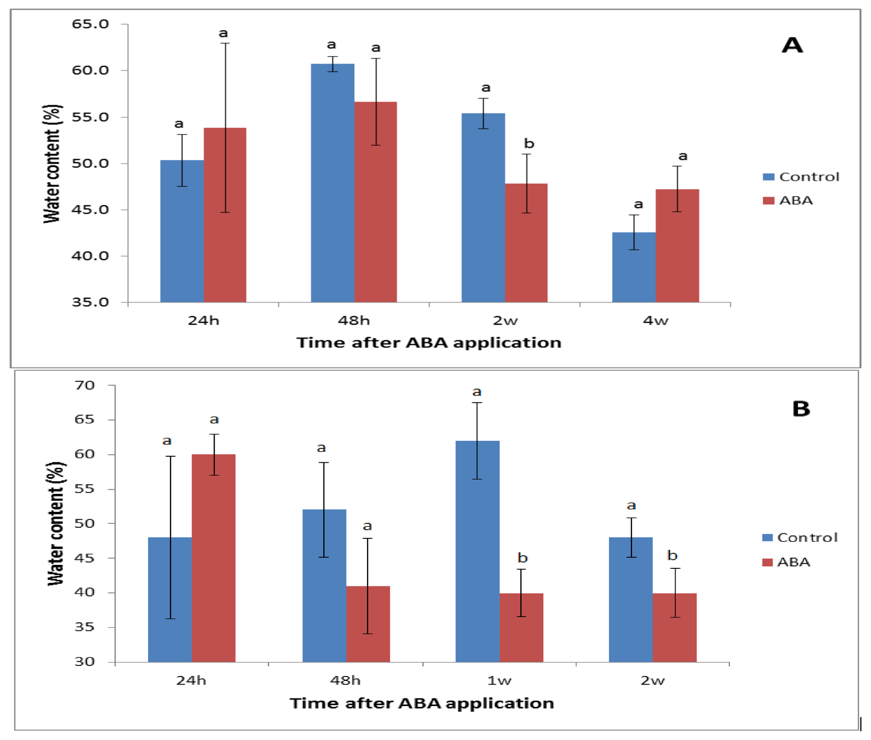

Figure 6. Effect of ABA on bud water content (%FW) of greenhouse-grown 'Cabernet franc' grapevines, A) Experiment 1, conducted in July, 2013, B) Experiment 2, conducted in Nov, 2013.

Conclusions

- The application of ABA did not affect yield components or fruit composition, but caused early leaf abscission, advanced bud dormancy, decreased bud water content, and eventually increased freezing tolerance.
- Optimum ABA application timing in Pinot gris: Veraison and Post-veraison.
- ✓ Veraison and Post-veraison treatments had the most effect on dormancy.
- ✓ Veraison and Post-veraison treatements had the lowest LT50s and showed significant differences compared to Control.
- ABA caused desiccation of buds which was associated with increased freezing tolerance.

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